

CLAIMS

WHAT IS CLAIMED IS:

1. A method of monitoring an object, the method comprising:
providing a composition comprising a population of nanocrystals that emit nonvisible light when excited;
tagging the object with the composition;
exciting the nanocrystals on the tagged object to emit the light; and
detecting the nonvisible light emitted from the composition, thereby monitoring the object.
2. The method of claim 1, wherein the object comprises: an article, a material, an article of commerce, an analytical sample, an animal, a medical diagnostic, or a medical device.
3. The method of claim 1, wherein the nanocrystals comprise a semiconductor, a nanodot, a nanorod, a nanowire, a branched nanorod, a nanocrystal, a nanocrystal, a coated nanocrystal, a passivated nanocrystal, or a derivitized nanocrystal.
4. The method of claim 1, further comprising manufacturing the nanocrystals, wherein manufacturing comprises colloidal synthesis, precipitation, monolayer self assembly, photolithography, VLS growth, gas-phase nucleation and growth, solution-phase nucleation and growth, or vapor deposition.
5. The method of claim 1, wherein the population of nanocrystals comprises two or more subsets of nanocrystals, the subsets comprising different light emission characteristics.
6. The method of claim 1, further comprising tuning the nanocrystals to adjust an excitation wavelength, excitation polarity angle, emission wavelength, emission polarity angle, emission spectral width, or intensity of emission of the nanocrystals.
7. The method of claim 6, wherein the tuning comprises controlling a size of the nanocrystals, a shape or pattern of the nanocrystals, a polarization of the nanocrystals, a size-distribution of the nanocrystals, a composition of the nanocrystals, a mass percentage of a nanocrystal constituent, or a representation of a nanocrystal subset.

8. The method of claim 1, wherein an emission wavelength of the nonvisible light comprises UV or IR wavelengths.

9. The method of claim 1, wherein the population of nanocrystals comprises two or more subsets of nanocrystals, the subsets having one or more different excitation wavelengths.

10. The method of claim 1, wherein the composition further comprises an adherent matrix.

11. The method of claim 1, wherein the composition comprises nanocrystals coated onto a substrate material.

12. The method of claim 10, wherein the adherent matrix comprises a polymer, a glass, a crystal, an organic material, an inorganic material, a liquid, a penetrant, a solid support, tape, a patch, a fiber, a capsule, a powder, a decal, a pin, a clip, a label, ink, or an adhesive.

13. The method of claim 1, wherein tagging comprises: depositing, spraying, brushing, taping, combining, mounting, injecting, blending, wiping, vaporizing and deposition, painting, inscribing, stamping, sticking, pinning, or applying the composition into or onto the object.

14. The method of claim 1, wherein tagging comprises applying the composition to the object in a shape or pattern.

15. The method of claim 1, wherein tagging comprises cumulative tagging wherein additional nanocrystal subsets are tagged to the object over time.

16. The method of claim 1, wherein exciting comprises illuminating the object with an ultraviolet light source, visible light source, or infrared light source.

17. The method of claim 16, wherein the light source comprises a laser, a light emitting diode, an incandescent lamp, a mercury vapor lamp, a deuterium lamp, a defraction grating, a prism, a light filter, the sun, or fluorescence from other molecules in the composition.

18. The method of claim 1, wherein detecting comprises receiving nanocrystal emissions by a light sensor, a photodiode, a CCD, a CMOS sensor, a photodiode array, a photomultiplier tube, a fluorometer, a detector array, an image array, a camera, a spectrophotometer, or an eye.

19. The method of claim 1, further comprising decoding the detected emission wavelengths.

20. The method of claim **19**, wherein the decoding comprises evaluating: excitation wavelengths, excitation polarization angles, emission frequencies, emission frequency combinations, emission shapes or patterns, emission polarization angles, emission intensities, or emission spectral widths.

21. The method of claim **1**, wherein exciting comprises illumination with UV light, visible light, IR light or near IR light, and wherein detecting comprises receiving UV or IR light emissions.

22. The method of claim **1**, further comprising monitoring the object through a barrier.

23. The method of claim **22**, wherein the barrier comprises living tissue, organic tissue, vegetation, animals, smoke, screens, dust, plastics, clouds, rain, water, a fabric, a material that transmits nonvisible light, or visibly obscured lines of sight.

24. The method of claim **22**, wherein the exciting comprises illumination with IR light and the detecting comprises receiving IR light.

25. The method of claim **1**, further comprising linking the nanocrystals to a biomolecule, an insulating molecule, a hydrophilic molecule, a hydrophobic molecule, or solid support.

26. A composition, comprising:

a population of nanocrystals comprising an excitation spectrum and an emission spectrum, wherein the emission spectrum and at least a portion of the excitation spectrum are in the nonvisible range;

wherein the population of nanocrystals are disposed in an adherent matrix or suspended in a solution suitable for administration to a mammal.

27. The composition of claim **26**, wherein the nanocrystals comprise: a semiconductor, a nanodot, a nanorod, a nanowire, a nanocrystal, a branched nanorod, a coated nanocrystal, a passivated nanocrystal, or a derivitized nanocrystal.

28. The composition of claim **26**, wherein the nanocrystals further comprise a diameter ranging from about 1000 nm to about 0.1 nm.

29. The composition of claim **28**, wherein the nanocrystals further comprise a diameter ranging from about 50 nm to about 15 nm.

30. The composition of claim **27**, wherein the derivitized nanocrystal comprise a linking agent selected from the group consisting of a substituted silane, a diacetylene, an acrylate, an acrylamide, vinyl, styryl, silicon oxide, boron oxide, phosphorus oxide, N-(3-aminopropyl)3-mercaptopropyl-benzamide, 3-aminopropyl-trimethoxysilane, 3-mercaptopropyl-trimethoxysilane, 3-maleimidopropyl-trimethoxysilane, 3-hydrazidopropyl-trimethoxysilane, a hydroxysuccinimide, a maleimide, a haloacetyl, a pyridyl disulfide, a hydrazine, and ethyldiethylamino propylcarbodiimide.

31. The composition of claim **27**, wherein coated nanocrystals comprise an inner core, and a coating layer of semiconductor comprising a band gap greater than that of the core.

32. The composition of claim **31**, wherein the nanocrystals comprise AlAs, AlN, AlP, AlSb, CdO, CdS, CdSe, CdTe, GaAs, GaN, GaP, GaSb, HgO, HgS, HgSe, HgTe, InAs, InN, InP, InSb, MgS, MgSe, ZnO, ZnS, ZnSe, or ZnTe.

33. The composition of claim **26**, wherein the nanocrystals comprise ZnS, ZnSe, ZnTe, CdS, CdSe, CdTe, GaN, GaP, PbTe, HgS, HgSe, HgTe, CdTe, GaAs, GaSb, InP, InAs, InSb, AlS, AlSb, PbS, PbSe, Ge, or Si.

34. The composition of claim **26**, wherein the population of nanocrystals comprises two or more subsets of nanocrystals, the subsets comprising different light emission wavelengths.

35. The composition of claim **26**, wherein a subset of the population of nanocrystals emits light with a spectral width from less than about 25 nm to about 30 nm.

36. The composition of claim **26**, wherein the nanocrystals are manufactured by colloidal synthesis, precipitation, monolayer self assembly, photolithography, VLS growth, gas-phase nucleation and growth, solution-phase nucleation and growth, or vapor deposition.

37. The composition of claim **26**, wherein the excitation spectrum comprises ultraviolet, visible, or infrared wavelengths.

38. The composition of claim **26**, wherein the population of nanocrystals comprises two or more subsets of nanocrystals, the subsets comprising different excitation wavelengths.

39. The composition of claim **38**, wherein the emissions of the population comprise different wavelengths or different wavelength intensities when alternately excited with the different excitation wavelengths.

40. The composition of claim **26**, wherein the emission spectrum comprises ultraviolet or infrared wavelengths.

41. The composition of claim **26**, wherein a subset of the nanocrystals comprises a predetermined intensity of emission at a wavelength.

42. The composition of claim **41**, wherein the intensity is predetermined by varying a concentration of a nanocrystal constituent, the presence of an overcoating, or by varying representation of the nanocrystal subset.

43. The composition of claim **26**, wherein administering to a mammal comprises delivering the nanocrystals through intravenous, intramuscular, intraperitoneal, intracerebrospinal, subcutaneous, intra-articular, intrasynovial, intrathecal, oral, topical, intranasal, or pulmonary routes.

44. The composition of claim **26**, wherein the population of nanocrystals comprises a predetermined excitation spectra or emission spectra.

45. The composition of claim **44**, wherein the spectra are predetermined by varying a size of a nanocrystal, a constituent semiconductor, a size-distribution of the nanocrystals, a composition of a nanocrystal, a polarization of a nanocrystal, or a concentration of a nanocrystal constituent.

46. The composition of claim **26**, wherein the adherent matrix comprises a polymer, a penetrant, a solid support, a glass, a crystal, an organic material, an inorganic material, a liquid, tape, a fiber, a patch, a capsule, a powder, a decal, a pin, a clip, a label, ink, or an adhesive.

47. The composition of claim **26**, wherein the composition is excitable or detectable through a barrier.

48. The composition of claim **47**, wherein the barrier comprises living tissue, organic tissue, vegetation, animals, smoke, screens, dust, plastics, clouds, rain, water, a fabric, a material that transmits nonvisible light, or visibly obscured lines of sight.

49. A system for non-obtrusive monitoring of objects, the system comprising:
a composition that includes a population of nanocrystals comprising excitation wavelengths and one or more nonvisible light emission wavelengths, which composition is tagging the object;

a light source adapted to excite the nanocrystals at the excitation wavelengths;
a light detector adapted to detect light emitted from the nanocrystals; and,
a logic device in communication with the detector, which logic device is adapted to interpret signals from the detector, thereby monitoring a presence, identity or location of the composition and the object.

50. The system of claim **49**, wherein the nanocrystals comprise: a semiconductor, a nanodot, a nanorod, a nanowire, a nanocrystal, a branched nanorod, a coated nanocrystal, a passivated nanocrystal, or a derivitized nanocrystal.

51. The system of claim **49**, wherein the population of nanocrystals comprises two of more subsets of nanocrystals, the subsets having different light emission wavelengths or different light emission intensities

52. The system of claim **49**, wherein the nanocrystals are disposed in an adherent matrix.

53. The system of claim **49**, wherein the light source comprises a laser, a light emitting diode, an incandescent lamp, a mercury vapor lamp, a deuterium lamp, a defraction grating, a prism, a light filter, the sun, or fluorescence from other molecules in the composition.

54. The system of claim **49**, further comprising a barrier between the object or composition and the light source or the light detector.

55. The system of claim **54**, wherein the barrier comprises living tissue, organic tissue, vegetation, animals, dust, plastics, smoke, clouds, rain, water, a screen, a fabric, a material that transmits nonvisible light, or visibly obscured lines of sight.

56. The system of claim **49**, wherein the light detector comprises a light sensor, a photodiode, a CCD, a CMOS sensor, a photodiode array, a photomultiplier tube, a fluorometer, a detector array, an image array, a camera, a spectrophotometer, or an eye.

57. The system of claim **49**, wherein the logic device comprises, an analog display, a digital display, or a computer system.

58. The system of claim **49**, wherein interpreting signals comprises decoding the signals, displaying a detection event, or storing detection event data.

59. The system of claim **49**, wherein the system is configured to monitor the location of retail articles, to monitor analytical samples, to monitor the identity or location of objects in transit, or to monitor the identity or location of objects within living tissue.